1 lRMS Sky Survey Techniques for Separating the Rare interesting Signal
from the Multitude of Background Signals

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The NASA High Resolution Microwave Survey (1 IRMS) Sky Survey component will survey the ent ire celestial sphere over the microwave frequency band spanning 1GHz, to 10 GHz to search for signals of intelligent origin which originate from beyond our solar system. Human technology has already reached a level which makes interstellar communication by means of microwave transmissions feasible. The problem is not one of difficult y of detect ion, but of search space and interference by t ransmissions of human origin.

Only a thin sliver of the microwave bane] is protected from all human transmissions. '1'bus, the Sky Survey will encounter many strong and variable signals of intelligent origin from fixed and mobile transmitters, low earth orbit and geosynchronous orbit satellites, as well as reflected signals from the. Moon and emissions from deep space probes.

The Sky Survey sweeps the sky rapidly in a sliding racetrack pattern which covers an area of the sky. During this "sky frame" observation, the antenna beam traverses a large angle cm the sky. The background noise power estimator must instantaneously react to changes causal by this movement, otherwise the thresholding algorithms would quickly saturate the data collection system. The threshold is set to allow a stca(iy-state rate of exceedences due to fluctuations in the system at a probability of false alarm of 1()-5 in the absense of interference.

Combining the beam chopping resulting from the sweeping action with the requirement that an extraterrestrial signs] must appear fixed in the sky with respect to the distant stars is a strong discriminator against many signals of human origin. A candidate signal must appear for a duration which is matched to the antenna beam traversal time of a fixed point in the. sky, and it must appear in an adjacent beam area which is swept at a later time if its reported intensity is sufficient.

Other techniques arc used in addition to spatial filtering to control data rate and eliminate radio frequency interference. The microwave frequency at which a candidate signal appears may report only a few such during the entire survey, otherwise it is likely infiltrated by terrestrial interference. If an excessive number of reports are generated by a frequency during data collect ion, that frequency is automat icall y masked to control t he report bandwidth. At the end of a sky frame observation and before data archieval, all hits arc sieved through the. final aggregate mask to remove all reports from those frequencies which generated excessive reports. Thus egregious interference forces the loss of search Space.

Archived hits are further tested in post processing to remove interference which was not severe enough to trigger masking. Interference which is sporadic or drifts in frequency during the course of the observation is detected by algorithms which associate hits over coarse grids in the Iimc-frequency domain. Again, since the antenna beam is pointing at different areas in the sky at each instant in time, contiguous patterns which appear in the time-frequency domain qualify as interference. The hits which make up these patterns arc excised from further consideration during the selection of candidates for reobservat ion.

Candidates are. selected from the survivors and reobserved in a dwell mode at higher sensitivity to determine whether they are detectable at the same celestial position, which has moved in the local frame due to the Earth's rotation.

A protot ypc system is current] y operating in the field for an average of 30 hours per week. We arc using it to verify our algorithms for signal detection and interference rejection while undertaking a small-scale survey of the sky. The detection statistics match theoretical expectat ions down to a probabilit y of false alarm of 1()-1 2 in interference.-free regions of the microwave band.

References:

Quirk, M. P., 11. C. Wilck, M. F. Garyantes and M. J. Grimm, "A Wide-Band 1 ligh-Resolution Spectrum Analyzer," IEEE Transactions on Acoustics, Speech and Signal I'recessing, vol. 36, no. 12, Dec., 1988, pp. 1854-1866.

Klein, M.J. and Gulkis, S., "The Impact of Technology on SETI," The Search foJ Extraterrestrial Life--The Exploration Broadens: Proceedings of the 3d Internl. Bioastronomy Symposium, Vai Cenis, France, June 18-23, 1990, Springer-Verlng, Heidelberg, 1991, pp. 203-2.09.

Olsen, E.T., Jackson, E.B. and Gulkis, S., "RFI Surveys at Selected Radio **observatories,'>** The **Search** for Extraterrestrial Life--The Exploration Broadens: Proceedings of the 3d Internl. Bioastronomy Symposium, Val Cenis, France, June 18-23, 1990, Springer-Verlag, Heidelberg, 199 1; pp. 21()-216.

Zimmerman, G. A., Garyantes, M.F., Grimm, M. J. and Charny, B., "A 640-MHz 32-Megachannel Real-Time Polyphase-FFT Spectrum Anal yzer, " TDA Progress Report 42-1-8, Nov. 15, 1991, pp. 132-140.

Olsen, E.T., Jackson, E.B. and Gulkis, S., "SETI Site Surveys of RFI in the Band 1.() GHz to 1 ().4 GHz," 'J'bird Decennial US-USSR Conference on SETI, Univ. of' Calif., Santa Cruz, August S-9,] 991, Astronomical Society of the Pacific Conference Series, Volume 47, 1993, pp. 313-321.

Levin, S., 1'. Asmar, D. Burns, C. Foster, M. Garyantes, R. Gosline, S. Gulkis, M.J. Klein, 11.'1'. Olsen, H. Wilck, and G. Zimmerman, "Preliminary Test Data from the SETI Microwave Observing Project Sky Survey Prototype", "1'bird Decennial US-USSR Conference cm SETI, Univ. of Calif., Santa Cruz, August 5-9, 1991, Astronomical Society of the Pacific Conference Series, Volume 47, 1993, pp. 349-356,

Zimmerman, G. and E. '1'. Olsen, "Analysis of]/() Efficient Order-Statistic-Based Noise Power Est imators," Proceedings of the international Conference cm Acoustics, Speach and Signs] Processing, San Francisco, CA, March 23-26, 1992.